A Novel Technique to Detect Epipelagic Fish Populations and Map their Habitat

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LONG-TERM GOALS

The ultimate goal of this project is to substantially improve our understanding of the relation between ecologically important key fish species (e.g. sardine and albacore) and the physical environment by collecting synoptic measurements with improved spatial and temporal resolution of observations.

OBJECTIVES

The overall objective of this work is to develop a new technique to detect epipelagic fishes and map their habitat and to test this technique in the EEZ of Oregon and Washington. The secondary objective is the analyze the array of spatial data collected to better understand the connection and affects of habitat and fish behavior on fish detection and distribution. The technique combines data from satellites, aircraft, ships, and moorings. Each platform covers a unique set of spatial and temporal scales, and each instrument has its own advantages and disadvantages. A technique combining data from multiple platforms can be much more powerful than any one alone.

APPROACH

Our partnership program is striving to develop a new method for detection of fish and synoptically mapping their environment at nested spatial and temporal scales. This new technique involves employing aerial data collection techniques (which are able to collect data at a much larger range of temporal and spatial scales than traditional methods) and coupling them with directed and coordinated ship-based observations, buoy data, and satellite-derived information. The nested array of observations are being analyzed and modeled in a GIS-based environment to provide qualitative and quantitative views of habitat- and behavioral- induced fish distribution patterns.

WORK COMPELETED

Data collected during field seasons in the summers of 2005 and 2006 have now been processed and we are now in the synthesis phase of the project. In the past year we have coordinated efforts among the project collaborators to begin to combine satellite data, airborne LIDAR and radiometer data, shipborne fish and plankton sampling data, shipboard acoustic echosounder data, and acoustic mooring data for spatial and temporal relationships.

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14. ABSTRACT
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15. SUBJECT TERMS

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Two acoustic buoy moorings were deployed near the mouth of the Columbia River in August of the first year of fieldwork, and four acoustic buoy moorings were deployed northwest of the mouth of the Columbia River in June the second year of fieldwork. Acoustic data of fish schools and zooplankton distributions collected in years 1 and 2 have been processed using acoustic software Echoview. Methods to consistently identify biological features including fish schools and periods of anomalously high zooplankton patches from the 200 kHz echosounder moorings continue to be developed and improved. Early results of these data have provided important information on school behavior and distribution over the tidal, circadian, and longer frequency patterns of variability.

Zooplankton samples collected by Bongo net sampling in 2006 were sorted to provide species composition information that will be used for understanding the fish prey-field. Body length measurements of these samples were also collected to apply acoustic models to Tracor acoustic profiling system (Taps) data on the vertical distributions of zooplankton. These data have been used to identify thin layers of zooplankton in the water column. Some layers were also observed in LIDAR data during this time.

We are now working to develop and refine our technique to integrate biological and environmental datasets collected from different platforms and over different spatial and temporal scales ranging from finescale distribution of fish prey to shelf-wide distribution of fish. This integration includes data from;

- Airborne LIDAR
- Sea-surface temperature
- Shipboard EK60 scientific echosounders
- Stationary acoustic echosounders
- CTD profiles
- TAPS profiles
- Satellite environmental data
- Fish trawl sample data
- Zooplankton sample data

RESULTS

Significant results from this work include important information on the behavior of schools and how these behaviors may influence our ability to remotely detect them. A key component of stock assessment of schooling populations is going to be understanding the behavioral aspect of schooling. Results from our analysis have shown a strong circadian pattern of schooling, with most schools detected during the daytime and few schools at nighttime. There also appears to be a diel pattern of depth distributions for some schools, however our fish trawls integrate samples collected near surface so we are unable to identify species-based differences in vertical distributions.

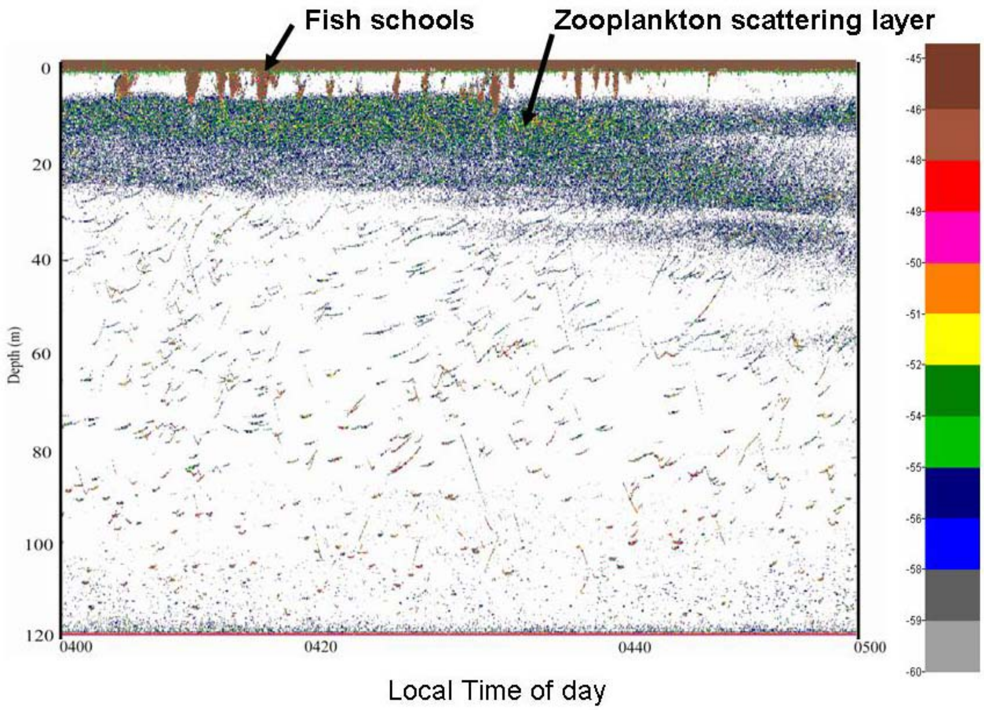

Figure 1. Echogram from acoustic buoy data collected over a 1-hour period during early morning (04:00 – 05:00). In this data, several small schools are clearly distinguishable near surface where they are also detectable by airborne LIDAR. However, since many of these schools are within 5 meters of the surface, they are not detectable by shipboard acoustics.

At nighttime, most schools disperse and distinct schools were generally not detectable. Schooling fish appeared to disperse both horizontally and vertically in the water column. Techniques that rely on detection of high aggregations of fish in schools are therefore limited to daytime surveys. However detection of single fish targets may still be available.

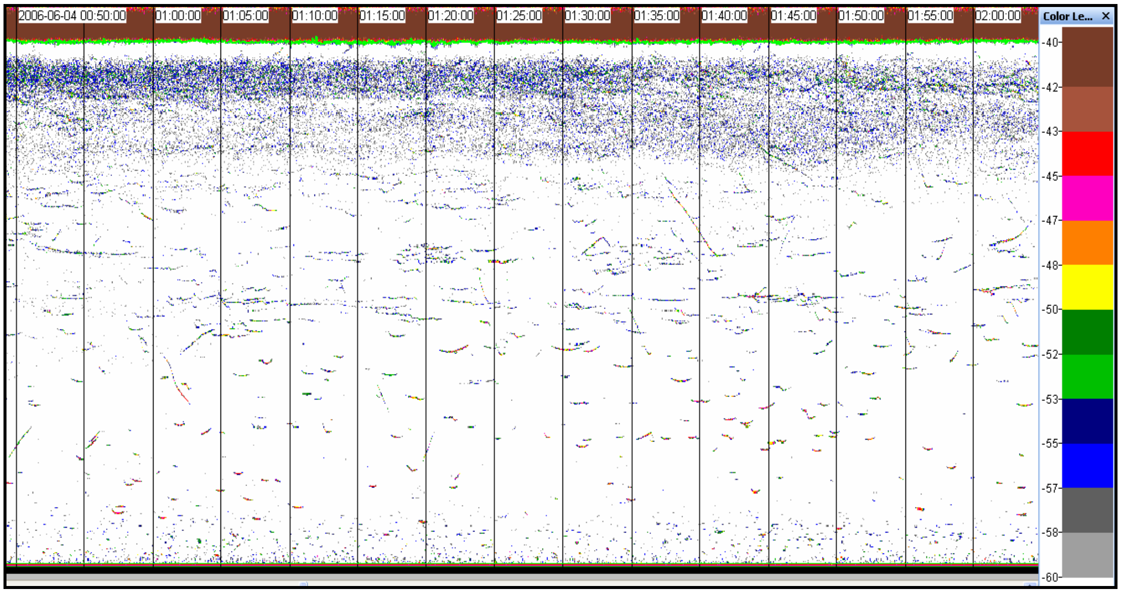

Figure 2. Example of a one-hour nighttime echogram (01:00 – 02:00), showing fish highly dispersed throughout the water column.

IMPACT/APPLICATIONS

While still in its synthesis stage, this project will:

1. Refine Fish LIDAR data processing techniques and test the results by a comparison with echo sounder, airborne video, trawl, and quantified aerial survey visual observation data. Particular attention will be paid to taxa identification in aerial surveys using LIDAR depolarization, school morphology, and habitat clues.

2. Develop a technique to combine LIDAR, echo sounder, and sampling data to produce a species-specific measure of fish distribution. The first step will be to develop a technique to combine the data into a consistent index of abundance. We will then try to develop an accurate number density estimate.

3. Develop a technique to design the most accurate fish survey for a fixed cost. This will use adaptive sampling strategies where a low-cost LIDAR survey directs an echo sounder survey to the most productive regions within the habitat. The echo sounder survey, in turn, is used to design trawl placement to get the maximum amount of information.

4. Develop GIS-based techniques to quantitatively relate the distribution of epipelagic fishes to their habitat.

5. Better understand how the dynamics of school behavior influence the ability to detect and quantify fish populations.

RELATED PROJECTS

The comparison of LIDAR and acoustic sampling techniques for assessing biology in this work is strongly related to the collaboration between Benoit-Bird and Concannon and Prentice (NAVAIR). Concannon and Prentice are funded through ONR under the LOCO DRI and Benoit-Bird through the YIP program. This project seeks to compare airborne LIDAR and ship and moored acoustics, focusing primarily on fish as targets while the LOCO project compares ship-based LIDAR with ship and moored acoustics primarily focusing on plankton as targets.

PUBLICATIONS

Kaltenberg, AM; Benoit-Bird, KJ; Brodeur, RD; Brown, ED; Horne, JK; Churnside, JH. (2006) A Study of Sardines in the NE Pacific Using Multiple Platforms and Technologies. EOS Trans., AGU, Vol. 87, no. 36, Ocean Sci. Meet. Suppl., Abstract OS421- 05.